Union of Concerned Scientists

EXPLAINER

Energy Storage in California

In 2018, California committed to the ambitious goal of transitioning to 100 percent clean electricity by 2045. The state has begun the process of answering a series of complex questions, including how to continue to meet the energy needs of an ever-growing state, how to ensure energy is reliably supplied to those who need it, and how to continue to integrate renewable energy and reduce dependence on polluting fossil fuels. As Californians wrestle with these questions, many have turned to energy storage as one piece of this puzzle.

What Is Energy Storage?

Simply put, energy storage encompasses a range of technologies that provide a way to manage energy supply and demand. Energy storage can play an important role in the complex system that is the electricity grid. When attached to a residential home, it can provide a reliable electricity supply even when that home is not receiving electricity from the grid (this is often called "behind the meter" storage). When implemented at utility scale, it can help integrate renewables and assist with the transmission and distribution of energy across the state (often called "in front of the meter" storage). If California is to solve the many challenges to achieving a 100 percent clean electricity future, storage must be a part of the solution.

The use of energy storage is certainly not new, but as California makes its clean energy transition, additional storage can offer needed flexibility and reliability. Indeed, storage provides several benefits for energy consumers and producers alike:

- **Helps meet energy demand:** Energy storage helps manage the balancing act between electricity supply and demand. When supply is high and demand is low, storage can store excess energy for later use, preserving the value of that energy. When demand is high and supply is low, storage can discharge stored energy to the grid for use, avoiding outages or shortages.
- **Strengthens the grid:** Due to its ability to discharge energy quickly when needed, energy storage can rapidly respond to changes on the electricity grid. This may mean discharging stored energy to help meet unexpected spikes in electricity demand or providing backup power in the case of outages. Energy storage can help add flexibility and resilience to the systems that our cities and neighborhoods rely on for energy.
- **Supports the integration of renewable energy:** While some renewable energy technologies—such as wind and solar—experience intermittent periods of "down-time" during which energy cannot be produced, electricity demand must still be met. Storage helps plug these gaps by providing energy during these periods of variable output, stabilizing the electricity supply.

Just as storage can provide several benefits, it can also take many forms and occupy many roles. Although batteries are the most recognized form of energy storage, today's portfolio of storage technologies is diverse and expanding due to research and development efforts around the world. Energy suppliers often rely on a combination of storage technologies, each serving a different purpose within the greater grid system. We discuss some of the most notable storage technologies in Table 1:

Table 1. Most Notable Storage Technologies.

Technology	Strengths	Weaknesses	Maximum Power Rating (MW)	Discharge Time
Batteries	Can be placed anywhere, allowing versatile storage deployment for several uses ranging from co-location with generation to local reliability.	Currently not cost-effective for resolving significant long-duration storage needs.	~0.1 to 100	Minutes to Hours
Pumped Hydropower	Reliably and flexibly meets long-duration storage needs—often for the purposes of bulk power management.	Very costly and potentially environmentally disruptive (usually resulting in long permitting and construction periods). Hydropower's reliance on large reservoirs of water also imposes geographical limits and issues related to weather variability.	~100 to 1,000	Hours to Days
Thermal	Ubiquitous and reasonably effective at providing energy storage on a large scale.	Converting stored thermal energy to usable electricity is often inefficient and not cost-effective.	~1 to 100. Varies depending on the type of system	Hours. Varies depending on the type of system
Compressed Air	Able to discharge energy over long periods of time.	Less efficient and more costly than other storage technologies. Like hydropower, it is geographically limited due to its reliance on underground reservoirs.	~10 to 1,000	Hours to Days
Flywheels	Quick and efficient rate of energy discharge.	Ineffective for long-duration storage needs.	~0.001 to 1	Seconds to Minutes

Table 1. Energy storage encompasses a variety of different technologies, each serving different roles on the electricity grid. For a more in-depth review of storage technologies, visit our storage explainer. Note: Some early-stage demonstration flywheels have reached closer to four-hour durations. SOURCES: Gur 2018; Zablocki 2019; World Energy Council 2020; World Energy Council 2019.

Energy Storage in California: Assembly Bill 2514 and Meeting Our Goals

In 2010, California took a major step to accelerate energy storage deployment with the passage of Assembly Bill 2514 (AB 2514). The bill directed the California Public Utilities Commission (CPUC) to evaluate the feasibility of storage and determine appropriate procurement goals for California's electricity providers. Two years later, the CPUC issued Decision 13-10-040 establishing the state's first energy storage procurement target of 1,325 megawatts (MW) by 2020. California's AB 2514 goal was the first of its kind in the United States and remains one of the most ambitious storage mandates in the country.[1] Since 2013, California has continued to establish additional energy storage targets and goals. Table 2 highlights several foundational targets the state has set since AB 2514 was passed.

Table 2. Additional California Storage Targets

Bill	Mandate
AB 2868 (2016)	Accelerated the deployment of storage among California's three investor owned utilities (IOUs) by an additional 500 MW by 2024, with no more than 25% of that capacity being behind the meter storage.
AB 33 (2016)	Directed the CPUC and California Energy Commission (CEC) to evaluate the feasibility of long-duration bulk energy storage in supporting renewable energy integration.
SB 801 (2017)	Required Southern California Edison (SCE) to deploy 20 MW of energy storage in response to reliability needs. Additionally mandated the Los Angeles Department of Water and Power to identify 100 MW worth of energy storage procurement opportunities to address reliability concerns associated with the Aliso Canyon Natural Gas Storage Facility.

Table 2. Since the passage of AB 2514, California has passed several mandates that are among the most ambitious in the United States.

So now, almost a decade since California first established its keystone AB 2514 goal, how much progress has been made to reach this target? To date, the CPUC reports statewide procurement of more than 1,500 MW of energy storage, on track to surpass the state's 1,325 MW target. California's two largest IOU companies, Pacific Gas & Electric (PG&E) and SCE, have both indicated to the CPUC that, as of March 2020, they have the energy storage contracts in place to meet their respective AB 2514 targets. California's third IOU, San Diego Gas & Electric (SDG&E), is still seven MW short of its storage targets—although it has indicated to the CPUC that it is still on track to meet its goals with additional solicitations by the end of 2020 (SDG&E 2020).

Figure 1. California's 2020 Storage Procurement

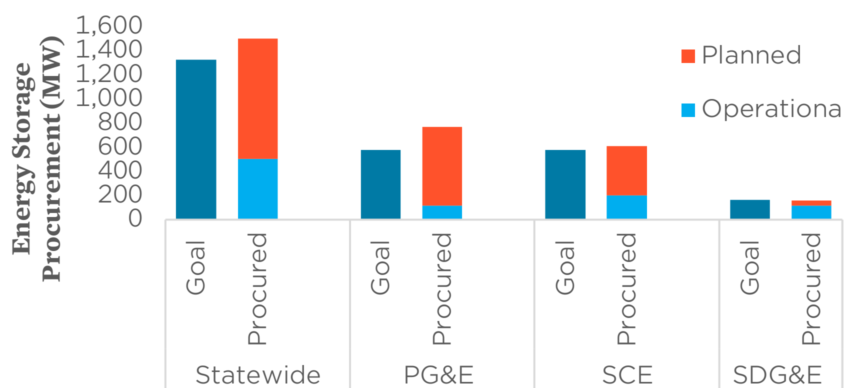

Figure 1. California is on track to meet the storage procurement goals set by AB 2514. All three of the state's public utility companies are on track to meet their respective targets.
SOURCES: PG&E 2020; SCE 2020a; SCE 2020b; SDG&E 2020.

Energy Storage in California: Headwinds and Tailwinds

With California well on its way to meet its AB 2514 storage targets, the state must now turn its attention to future procurement of storage capacity. The state currently has more than 1,000 MW of planned storage projects coming online in the next few years.[2] This is a start, but California will need much more energy storage to meet its ambitious goal of using 100 percent clean energy by 2045.

CALIFORNIA'S POST-2020 ENERGY STORAGE OUTLOOK

How much energy storage does California need? This is a complex question, and the answer depends on a host of factors, including state policy decisions and rapidly changing technology costs. Although it is unclear precisely how much energy storage California will need within the next decade, experts estimate that, at a minimum, roughly 10,000 MW will be needed by 2030 and at least triple that by 2040. Furthermore, many of these storage additions will need to be able to discharge in excess of four hours. Most current projections suggest that California will need at least seven times the storage procurement it is currently mandating in 2020 within the next 10 years. Figure 2 outlines just a handful of these projections, and although these numbers are not set in stone, they further illustrate the significant ramp-up energy storage likely must make by 2050 to support renewable integration and manage energy demand.

Figure 2. Estimates for California's Energy Storage Needs Beyond 2020.

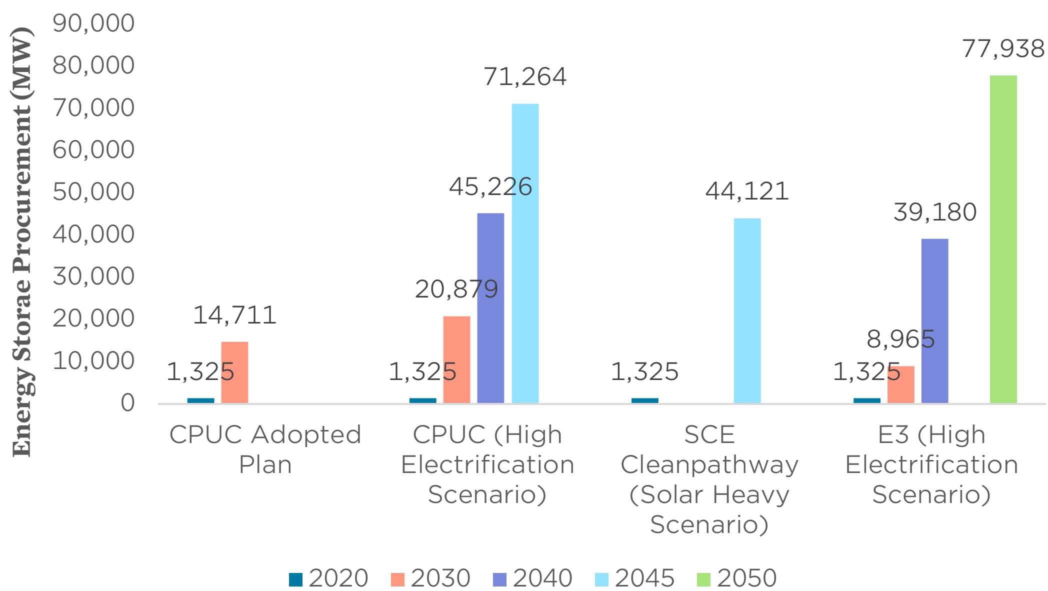

Figure 2. Experts estimate California will need a substantial increase in storage capacity by 2050. SOURCES: CPUC 2020; CPUC 2019; SCE 2019, E3 2019.

THE GOOD NEWS FOR ENERGY STORAGE IN CALIFORNIA

While these estimates are ambitious, California is well positioned in many respects to meet this challenge. Nationally, energy storage has seen continued and consistent growth. The most recent reports from the tail end of 2019 indicate that total nationwide storage deployment has experienced 33 percent year-over-year growth, with front of the meter storage in particular growing rapidly by a rate of 160 percent year-over-year in 2019 alone (WMPR 2020). California is notably one of the few states spearheading the storage boom in the United States. In 2019, the state was the nationwide leader in both residential and nonresidential storage deployment (WMPR 2020). And there is good reason to be optimistic about this growth continuing. Storage deployment in the United States is projected to expand to 7.3 gigawatts by 2025, about 14 times the current national capacity, and could be a $7.2 billion annual market in the next five years (WMPR 2020). The cost of storage, too, is expected to fall by up to 67 percent by 2030 and 80 percent by 2050 due to technological innovation and economies of scale (Cole and Frazier 2019).

More good news for California's storage outlook are several innovative storage initiatives that have already been brought online in the state. In 2018, the state legislature passed Senate Bill 700 (SB 700) which authorized the continuation of the Self-Generation Incentive Program (SGIP) and made $830 million of funding available for behind the meter storage technologies through 2025. SGIP, as the name suggests, provides financial incentives to promising energy projects and is poised to support thousands of storage initiatives and innovative pilot projects throughout the state. Even without this renewed funding, some projects already in the works include PG&E's thermal storage trials, SDG&E's integrated solar photovoltaic storage initiative, and grid-scale zinc batteries being tested in San Ramon (CAISO 2019).

Additionally, SGIP, via its Energy Storage Equity and Resilience Budgets, offers funding for storage deployment in low-income and disadvantaged communities to build energy resilience equitably on a local level. One of SGIP's goals is to support storage projects in areas vulnerable to wildfires, which could include funding for residential storage devices (such as the Tesla Powerwall) that provide an energy source during fire-induced power shutoffs. Broadly, initiatives such as the Equity and Resilience Budget reflect California's position as a national leader in both implementing and designing equitable energy storage policies and rules. Indeed, California and New York are the only two states that have established broad equity-focused clean energy policies (Richardson 2019).[3]

BARRIERS TO ENERGY STORAGE IN CALIFORNIA

Although California is well positioned to take on the energy storage challenge of the post-2020 era, it must overcome a number of barriers. Political leaders and renewable energy proponents alike must take seriously the obstacles currently hindering storage development in the state. Legislators in particular can play a key role. When California established its first storage goals in 2013, they were not only remarkably ambitious, but also the first storage targets to be established at a state level. Since 2013, California has worked under the framework of AB 2514 to become the national leader in energy storage deployment (CSS 2019). Policy can and should play a key role in the future of energy storage as well. To fully realize the benefits of storage and achieve the goal of 100 percent clean electricity, California will need to make progress in the following areas:

- **Support technological advancement and innovation**: As California undertakes the transition toward a 100 percent clean electricity grid, technological advances in energy storage will play an important role. While most storage deployment currently operates at the individual customer level and supports short-distance energy distribution, storage will be increasingly called upon to support the entire grid with bulk storage and transmission support (long-distance electricity delivery). In other words, storage is currently most commonly utilized during the last stages of energy's journey from power plant to consumer, during which electricity is sent from local substations to individual homes. Storage, however, will need to be fully integrated into the rest of the stages as energy is moved from power plants, across long-distance transmission lines, and finally to local neighborhoods.

Simply put, as more renewable generation is added to the grid, storage will need to store more of that energy and release it over longer periods of time. In technical terms, this means storage must increase its energy capacity, or the total amount of energy that a storage system can store and discharge (measured in megawatt-hours). Although pumped hydropower has historically served this role, other storage technologies will need to take on some of California's long-duration storage needs. Programs such as the CEC's Electric Program Investment Charge are attempting to do just that, by holding solicitations for technological and scientific research into promising energy storage initiatives.

- **Refine rules around market participation**: While falling costs are making energy storage more and more attractive, market rules and inefficiencies may be constraining its deployment. In particular, the energy market has been slow to embrace storage as a "transmission asset" able to distribute energy across the grid. Current power market rules have had difficulty fully accounting for the value of all types of energy storage, regardless of their discharge durations. Benefits offered by storage, such as pollution reduction and output flexibility, are often overlooked, reducing its value in the market and putting it at a competitive disadvantage.

  The Federal Energy Regulatory Commission (FERC) therefore issued Order 841, which directed the nation's independent system operators to create market participation models in accordance with a set of standards meant to fully realize storage's market value and revenue generating ability and better account for the limitations of storage technology under market rules. California's Independent System Operator (CAISO) has since implemented several changes in compliance with the order, including creating its own storage participation model as a corollary to FERC's and conducting stakeholder engagement to address market-related barriers. CAISO is also in the final implementation stage of its Energy Storage and Distributed Energy Resources (ESDER) initiative to enhance storage participation and more broadly capture its value as a resource to support energy distribution. Initiatives such as ESDER serve as a starting point for opening the market to storage to fully realize its benefit.
- **Pair storage with renewable resources to reduce global warming emissions**: While California ought to be aggressive in adding additional storage to the grid, it should also be wary of the manner in which this storage is added and subsequently operated. Improper or ineffective use of energy storage in combination with renewable energy may in fact increase net heat-trapping emissions (Hittinger and Azevedo 2015). Specifically, if a storage system stores energy from a carbon-intensive source and displaces a less carbon-intensive energy source when it is discharged, the result is a net increase in emissions. Unfortunately, storing renewable energy alone does not fully solve this issue.

When a storage system stores clean energy instead of sending it directly to the grid, some of that energy is lost in the process. When the stored energy is discharged later, it may—due to these efficiency losses—ultimately displace less carbon dioxide than it would have if the energy had been immediately sent to the grid for use. Proper planning of storage and discharge timing is therefore essential.

What can California do to avoid this problem? Naturally, one solution is to use storage to capture excess renewable generation that would otherwise be curtailed. For example, many solar power plants in California could produce even more energy, but transmission system limitations and design limitations of the solar power plants themselves prevent this energy from being produced; however, energy storage installed alongside these solar power plants could be used to capture and store that clean energy. Granted, California is not yet close to charging storage primarily from electricity generation that would otherwise be curtailed. Significant work will have to be done to increase both renewable energy and storage deployment in order to reach that point. Nonetheless, it is a goal the state must pursue if it is to unlock the full emissions-reducing potential of energy storage.

California's response to the barriers facing energy storage will be instrumental to storage's future in the state. If policymakers and industry leaders take these barriers seriously but consider them challenges rather than blockades, storage will be a golden opportunity for California to reduce renewable energy curtailment, shore up the grid's reliability, and support increased penetration of wind and solar energy. With continued support, storage will play a key role in meeting California's SB 100 targets. As more clean energy is added to the grid, the demand for energy storage will only rise. In short, energy storage presents an exciting opportunity for clean energy proponents in California—and the state should take full advantage of this opportunity.

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ENDNOTES

1. A review of every state's energy storage policies can be found using DSIRE's Database of State Incentives for Renewables & Efficiency: https://www.*dsireusa*.org/.
2. This figure reflects the CPUC's estimate at the time of access (August 2020). For more information, see https://www.cpuc.ca.gov/General.aspx?id=3462 .
3. For more information on how to support equitable energy storage policy, please refer to the Union of Concerned Scientists Policy Brief How to Ensure Energy Storage Policies are Equitable.

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